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Design of Experiments (DOE)

The Design of Experiments (DOE) methodology is traditionally associated with a testing environment. It is an attempt to address the cost/time issue of test programs and to generate more useful data from a given program. Can this DOE methodology also be used in the modeling and simulation world? SURVIAC personnel performed a proof-of-concept study looking at survivability enhancement features.

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Geographic Information Systems – Homeland Security

Fighting the global war on terrorism has forced the rethinking of traditional methods of intelligence gathering and operational analysis. The Standing Joint Force Headquarters in Norfolk, Virginia has led the way in developing new methods of “seeing – understanding – and acting first.” One key to successful execution of the Standing Joint Force Headquarters – Homeland Security’s (SJFHQ-HLS) mission was the fusion of timely, up-to-date (1) threat data (including multi-source intelligence and law enforcement [LE] information), (2) critical infrastructure information, and (3) operational information in a common operational picture (COP) to support mission planning and execution. A critical construct in maintaining situational awareness (SA) within SJFHQ-HLS was to use information derived from Geographic Information Systems (GIS) to effectively fuse, analyze, assess, and disseminate information between Department of Defense and interagency partners. This was especially true for civil support (CS) missions where the non-Department of Defense Federal, State, and local participants already use their own GIS for analysis and maintenance of situational awareness. SURVIAC leveraged GIS technology to establish a process and Standard Operating Procedures (SOPs) to build and maintain situational awareness for key events during SJFHQ-HLS’ crisis response operations (any time a credible threat warranted such production), and for critical National Special Security Events (NSSE) planning.

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Design of Experiments (DOE) (continued)

When dealing with survivability analysis, the types of parameters of interest deal with vulnerability and susceptibility. When using DOE in this manner, each of the vulnerability reduction features (e.g., VUL-1, VUL-2, VUL-3) and each of the susceptibility reduction features (e.g., SUS-1, SUS-2) is considered a factor, or variable. For a given number of factors, an appropriate test matrix is defined. The HIGH and LOW settings required by DOE would be "feature ON" for HIGH and "feature OFF" for LOW. The test matrix also defines the number of experiments to be conducted. In this case, "experiments" would be runs of the model or simulation. The test matrix would define the number of computer runs and the level settings for each instance. The test matrix used in the study is shown below.

Test Matrix

Test Matrix								
Run		Contrast Labels						
No.	Response	A	B	C	D	E	F	G
1		LOW	LOW	LOW	LOW	LOW	LOW	LOW
2		LOW	LOW	LOW	HIGH	HIGH	HIGH	HIGH
3		LOW	HIGH	HIGH	HIGH	HIGH	LOW	LOW
4		LOW	HIGH	HIGH	LOW	LOW	HIGH	HIGH
5		HIGH	HIGH	LOW	LOW	HIGH	HIGH	LOW
6		HIGH	HIGH	LOW	HIGH	LOW	LOW	HIGH
7		HIGH	LOW	HIGH	HIGH	LOW	HIGH	LOW
8		HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
	Main Effects	A	B	C	D	E		
	Two-Factor							
	Interactions	-BxC	-AxC	-AxB	-AxE	-AxD	-AxG	-AxF
		-DxE	-DxF	-DxG	-BxF	-BxG	-BxD	-BxE
		-FxG	-ExG	-ExF	-CxG	-CxF	-CxE	-CxD

The DOE methodology would calculate the effect each of these factors had on the response variable (typically probability of kill) and which feature had the greatest impact. In addition, DOE output would provide calculations on the effect of interactions between the various factors on the response variable. These calculations would provide excellent estimators of the synergism between the various features. This type of information could provide marginal cost and benefit estimates of the various combinations of features being considered.

Results of the study are presented below.

Analysis Results

	SS	DF	MS
Corrected Total	0.40999	7	0.05857
Between Groups	0.00911	1	0.00911
-A x C, CxDxE	0.02531	1	0.02531
C VUL-3 (OFF v ON)	0.11761	1	0.11761
-A x B, BxDxE	0.08201	1	0.08201
D SUS-1 (OFF v ON)	0.05281	1	0.05281
-A x E, BxCxE	0.00061	1	0.00061
E SUS-2 (OFF v ON)	0.12251	1	0.12251
-A x D, BxCxD			
F -BxD, -CxE, AxBxE, AxCxD			
G -BxE, -CxD, AxBxD, AxCxE			
Total			

The ability to provide insights into factor synergisms is a very important contribution that DOE analysis can provide to the entire analytical process that other analytical techniques cannot. Results of the analysis show that the factor VUL-3 (Armor the ammunition drum) is the most significant individual factor, while factor SUS-1 (Use of jamming and other ECM tactics) is the second most significant individual factor. However, the two factor interaction between VUL-2 (Harden the fuel tanks and dry bays) and SUS-2 (Use active defense suppression), or the two factor interaction between VUL-3 and SUS-1, is more significant than either of the individual factors alone. This is information that would not be available from a more traditional analysis.

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Geographic Information Systems – Homeland Security (continued)

SURVIAC developed a template that provided a capability to perform “red dot – blue dot” (threat vs. vulnerability) analysis and visualization using commercial-off-the-shelf GIS tools. The GIS template was useful in helping to identify, track, and report suspicious behaviors that suggested possible terrorist cell planning, surveillance, and probing of targets important to the Department of Defense. The resulting product from the GIS data, technology, and process provided situational awareness of potential enemy threats against friendly vulnerabilities in support of force protection, force projection, critical infrastructure protection, and force command and control.

These SURVIAC activities have had a far-reaching effect as SJFHQ-HLS’ parent command, US Northern Command (headquartered in Colorado Springs, Colorado) adopted many parts of the situational awareness process, technology, and procedures in developing their own Common Operational Picture (COP) Concept of Operations (CONOPs). Additionally, the Department of Homeland Security and the Assistant Secretary of Defense for Homeland Defense are embracing these same templates, technologies, and processes, developed by SURVIAC, in their own evolving Homeland Security processes. The use of “Location Awareness” as evidenced in the use of GIS as the central core of these tools is becoming widespread within Department of Defense as well as in State and local Homeland Security entities.

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